TRANSLATION

INVESTIGATION OF A HYSTERESIS LOOP OF COBALT NICKEL FERRITES

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INVESTIGATION OF A HYSTERESIS LOOP OF COBALT-NICKEL FERRITES

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Hysteresis loops of ferromagnetic ferrites can be divided into three types: normal, contracted and rectangular.

The majority of ferrites have a normal loop. It is characterized by the fact that the relation of remanence B_r to saturation B_s for a given field H is less than or equal to 0.5.

A contracted loop is obtained by slow cooling nickel and nickel-zinc ferrites with admixtures of CoO [1]. According to the authors, it corresponds to a microhetrogeneous system comprised of two types of crystals of similar structure with slightly different parameters.

In twin ferrites of Ni, Mn, Pb, Cu, Cd, Zn, and Mg containing admixtures of CoO and slowly cooled a contracted loop was observed with measurements in average-strength fields. A certain excess of Fe_2O_3 aids in the appearance of a contracted loop [2].

A rectangular loop has $B_r/B_s \geq 0.75$ and clearly expressed angles in the second and fourth quadrants (Fig. 1). The rectangularity can be spontaneous or induced. Ferrites with a rectangular loop can be used in the memory units of computers.

The investigation of the influence of admixtures of CoO to a hysteresis loop of nickel-zinc ferrites indicated that with 1-2% CoO, ferrites of certain compositions have a spontaneous rectangular loop [3]. The authors show that the maximum value B_r/B_s = 90-92% is obtained with a field strength H which is five times in excess of the coercive force of ferrites.

Induced rectangularity appears as a result of the thermomagnetic treatment of ferrites which yield the contracted loop, if the magnetic field direction during heat treatment and during measurement is the same [2].

The purpose of this article is to investigate the influence of the composition, heat treatment, and thermomagnetic treatment on the hysteresis loop of cobalt-nickel ferrites.

Heat treatment; contracted loop. For measuring, we used the ferrites $Co_xNi_{1-x}Fe_2O_4$ when x = 0.1 — 0.8 obtained by our previously-described method [4]. Samples of ferrites in the form of toroids were subjected to sintering: outside diameter 11 mm, inside diameter 6 mm, height 3 mm. After sintering the toroids had an outside diameter of 10.4 mm, an inside diameter of 5.7 mm and a height of 2.1 mm.

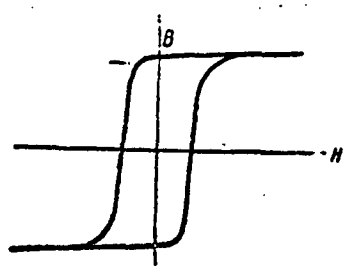

Fig. 1. A rectangular hysteresis loop of a ferrite.

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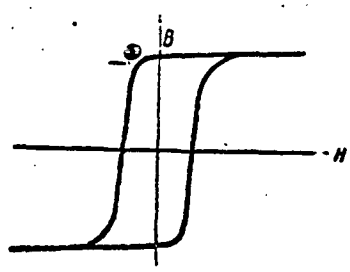

Fig. 1. A rectangular hysteresis loop of a ferrite.

The heat treatment of samples of the first series ended with tempering.

Samples of the second series, after tempering, were heated to 900° (300 – 400° higher than the Curie point), were held for one hour, and were cooled at the rate of 25, 50 and 100° per hour.

Measurement of the hysteresis loop was carried out at a frequency of 50 cps on an oscillograph equipped with an integrator. To avoid heating during the measurement, the sample was blown with compressed air.

The results of the measurements are given in the table and in Figure 2 (a, b, c, d).

The tempered samples have a normal loop with $B_r/B_s = 0.3 - 0.4$, increasing slightly with an increase of x (Fig. 2a).

Samples cooled at the rate of 50° per hour have, in a field of 85 oersteds, a normal loop when $x = 0.1$, 0.2, 0.7, 0.8, and a straight line when $x = 0.3$, 0.4, 0.5, and 0.6. With an increase of the field to 160 oersteds the straight line changes to a contracted loop (Fig. 2b). The contraction is more distinct with an increase in the field to 240 oersteds (Fig. 2c).

Only a normal loop is observed with a cooling rate of 25 and 100° per hour.

The appearance of a contracted loop when $x = 0.3 - 0.6$ confirms the presence of the transformations discovered by us in the region $x = 0.2 - 0.5$ [4].

Thermomagnetic Treatment; induced rectangularity. Samples of the second series with contracted hysteresis loops were subjected to 700 – 750° were realized by passing a direct current of 3 amp through a 20-turn winding of nichrome wire, with a diameter of 0.3 mm, on the toroid. Cooling was carried out at a rate of 300 – 350° per

hour by reducing the current to zero.

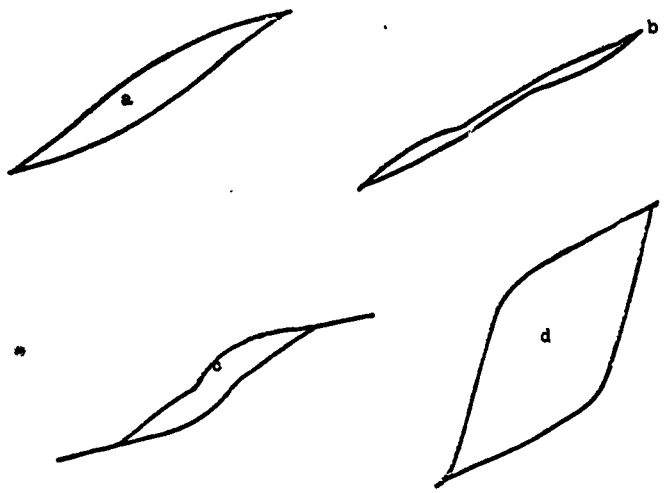

Fig. 2. Hysterisis loop of the ferrite $Co_{0.3}Ni_{0.7}Fe_2O_4$: a) after tempering; b) after cooling 50° per hour, H = 160 oersted; c) after cooling 50° per hour, H = 240 oersted; d) after thermomagnetic treatment.

TABLE 1

Hysteresis Loop of Ferrites $Co_xNi_{1-x}Fe_2O_4$ after Heat Treatment

Original state, x	Tempering	Cooling 50° per hour		
	Form of loop with H, oersted			
	85	85	160	240
0,1	Normal	Normal	Normal	Normal
0,2	Same	Same	Same	Same
0,3	Same	Straight line	Contracted	Contracted
0,4	Same	Same	Same	Same
0,5	Same	Same	Same	Same
0,6	Same	Same	Same	Same
0,7	Same	Normal	Normal	Normal
0,8	Same	Same	Same	Same

The loop measurement in a field of 85 oersteds yielded

B_r/B_s = 0.5 – 0.7 and indicated the presence of angles (Fig. 2d). This indicated the appearance of induced rectangularity. The attaining of a maximum value of B_r/B_s, however, requires a higher value of H.

Cooling at a rate of 25, 50, 100 and 200°, and also tempering, does not serve our purpose.

Conclusions

1. An investigation is carried out on the influence of the composition and heat and thermomagnetic treatment on the form of a hysteresis loop of ferrites $Co_xNi_{1-x}Fe_2O_4$.

2. It is established that after specific heat treatment ferrites have a contracted loop when x = 0.3 – 0.6.

3. It is found that thermomagnetic treatment changes the form of the loop, tending towards the appearance of induced rectangularity.

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